Amendments to the Specification

Please replace the Title with the following new Title:

-- METHOD FOR MAKING HIGH SPEED, HIGH AREAL DENSITY INDUCTIVE WRITE STRUCTURE --

Please insert on page 1, following line 5, the following new heading and paragraph:

CROSS-REFERENCE TO RELATED APPLICATION

This application is a Divisional of U.S. Application No. 09/617,791, filed July 18, 2000, which is hereby incorporated by reference in its entirety.

Please replace the two successive paragraphs running from line 12 on page 1 to line 3 on page 2 with the two following rewritten paragraphs:

Magnetic disk drives are used to store and retrieve data for digital electronic apparatus such as computers. In Figures 1A and 1B, a magnetic disk data storage system 10 of the prior art includes a sealed enclosure 12, a disk drive motor 14, one or more magnetic disks 16, supported for rotation by a drive spindle 18 of motor 14, and an actuator 20 including at least one arm 22, the actuator being attached to a pivot bearing 24. Suspensions 26 are coupled to the ends of the arms 22, and each suspension supports at its distal end a read/write head or transducer 28. The head [[24]] 28 (which will be described in greater detail with reference to Figures 2A and 2B) typically includes an inductive write element with a sensor read element. As the motor 14 rotates the magnetic disk 16, as indicated by the arrow R, an air bearing is formed under the transducer 28 causing it to lift slightly off of the surface of the magnetic disk 16, or, as its is termed in the art, to "fly" above the magnetic disk 16. Alternatively, some transducers, known as contact heads, ride on the disk surface. Various magnetic "tracks" of information can be written to and/or read from the magnetic disk 16 as the actuator 20 causes the transducer 28 to pivot in a short arc across a surface of the disk 16. The pivotal position of the actuator 20 is controlled by a voice coil 30 which passes between a set of magnets (not shown) to be driven by magnetic forces caused by current flowing through the coil 30.

Figure 2A shows the distal end of the head 28, greatly enlarged so that a write element 32 incorporated into the head can be seen. The write element 32 includes a magnetic yoke 34 having an electrically conductive coil 36 passing ~~there through~~ therethrough.

Please replace the seven successive paragraphs running from line 16 on page 2 to line 23 on page 4 with the following seven rewritten paragraphs:

The write element 32 can be better understood with reference to Figure 2B, which shows the write element 32 and an integral read element 38 in cross section. The head 28 includes a substrate 40 above which the read element 38 and the write element 32 are disposed. A common edge of the read and write elements 38, 32, defines an air bearing surface ABS, in a plane 42, which can be aligned to face the surface of the magnetic disk 16 (see Figures 1A and 1B). The read element 38 includes a first shield 44, a second shield 46, and a read sensor 48 that is located within a dielectric medium 50 between the first shield 44 and the second shield 46. The most common type of read sensor 48 used in the read/write head 28 is the magnetoresistive (AMR or GMR) sensor, which is used to detect magnetic field signal changes in a magnetic medium by means of changes in the resistance of the read sensor imparted from the changing magnitude and direction of the magnetic field being sensed.

The write element [[38]] 32 is typically an inductive write element that includes the second shield 46 (which functions as a first pole for the write element) and a second pole 52 disposed above the first pole 46. Since the present invention focuses on the write element 32, the second shield/first pole 46 will hereafter be referred to as the "first pole". The first pole 46 and the second pole 52 contact one another at a backgap portion 54, with these three elements collectively forming the yoke 34. The combination of a first pole tip portion and a second pole tip portion near the ABS are sometimes referred to as the ABS end 56 of the write element [[38]] 32. Some write elements have included a pedestal 55 which can be used to help define track width and throat height. A write gap 58 is formed between the first and second poles 46 and 52 in the area opposite the back gap portion 54. The write gap 58 is filled with a non-magnetic, electrically insulating material that forms a write gap material layer 60. This non-magnetic material can be either integral with or separate from a first insulation layer 62 that lies upon the first pole 46 and extends from the ABS end 56 to the backgap portion 54. The conductive coil 36, shown in cross section, passes

through the yoke 34, sitting upon the write gap material 60. A second insulation layer 64 covers the coil and electrically insulates it from the second pole 52.

An inductive write head such as that shown in Figures 2A and 2B operates by passing a writing current through the conductive coil [[30]] 36. Because of the magnetic properties of the yoke 28, a magnetic flux is induced in the first and second ~~poles 40 and 46~~ poles 46 and 52 by write currents passed through the coil [[30]] 36. The write gap [[52]] 58 allows the magnetic flux to fringe out from the yoke [[28]] 34 (thus forming a fringing gap field) and to cross the magnetic recording medium that is placed near the ABS.

With reference to Fig. 2C, a critical parameter of a magnetic write element is the trackwidth of the write element, which defines track density. For example, a narrower trackwidth can result in a higher magnetic recording density. The trackwidth is defined by the geometries in the ABS end 56 of the yoke. For example, the track width can be defined by the width W3 of the pedestal 55 or by the width W1 of the second pole 52, depending upon which is smaller. The widths W3 and W1 can be the same, such as when the second pole 52 is used to trim the pedestal 55. Alternatively, in ~~design~~ designs that have no pedestal at all it would be possible to define the trackwidth by the width W2 of the first pole.

With reference to Fig. 2B, the fringing gap field of the write element can be further affected by the positioning of the zero throat level ZT. ZT is defined as the distance from the ABS to the first divergence between the first and second pole, and it can be defined by either the first or ~~second pole 40, 46~~ second pole 46, 52 depending upon which has the shorter pole tip portion. Pedestal defined zero throat is defined by the back edge of the pedestal and is accomplished by moving the second insulation layer 64 back away from the ABS. Alternatively, zero throat can be defined by the geometry of the second pole 52, by allowing the second insulation layer 64 to extend over the top of the pedestal. In order to prevent flux leakage from the second pole [[46]] 52 into the back portions of the first pole [[40]] 46, it is desirable to provide a zero throat level that is ~~well defied~~ well defined with respect to the plane of the ABS. Furthermore, a pedestal defined zero throat is beneficially defined along a well defined plane that is parallel with the plane 42 of the ABS, whereas a zero throat defined by the second pole occurs along the sloped edge of the second insulation layer 64. As will be appreciated upon a reading of the description of the invention, the present invention can be used with either pedestal defined zero throat or a second

pole defined zero throat. Thus, accurate definition of the trackwidth, and zero throat is critical during the fabrication of the write element.

The performance of the write element is further dependent upon the properties of the magnetic materials used in fabricating the poles of the write element. In order to achieve greater overwrite performance, magnetic materials having a high saturation magnetic flux density (high B_{sat}) are preferred. A common material employed in forming the poles is high Fe content ([[55 at %]] 55% Fe) NiFe alloy having a B_{sat} of about 16kG. However, high Fe content NiFe alloy has a high magnetostriction constant λs (on the order of 10^{-5}) which causes undesirable domain formation in the poles. It is known that the domain wall motion in the writer is directly related to the increase in popcorn noise in the read element, especially when the motion occurs in the first pole, which also serves as a shield for the read element. A reduction in popcorn noise in the read element can be achieved through the use of soft magnetic materials, (i.e. materials having a low magnetostriction constant) in the fabrication of the ~~first pole 42~~ first pole 46. However, such materials generally have limited B_{sat}.

Therefore, there remains a need for a write element having the ability ~~to concentrate~~ to concentrate a high degree of magnetic flux in the ABS end of the write element, while minimizing or eliminating popcorn noise caused by magnetostrictive properties of the write element. Such a write element would preferably provide a narrow and accurately controlled trackwidth as well as providing high overwrite, low non-linear transition shift, a high areal density and high data rate.

Please replace the paragraph beginning at line 13 on page 5 with the following rewritten paragraph:

The present invention provides an inductive write element having improved magnetic performance characteristics, including high overwrite, low non-linear transition shift, high areal density and high data rate. The write element includes first and second poles, each constructed of a magnetic material and joined to one another to form a magnetic yoke. The poles are joined to one another at one end to form a back gap region, the other end having a write gap defined between the poles. An electrically conductive coil passes through the yoke between the ~~first and second pole~~ first and second poles, and insulating material electrically isolates the electrically conductive coil from the magnetic yoke. The second pole includes a layer of a laminated high magnetic moment

material, sputter deposited as a sheet film across the inner surface of the pole adjacent to the insulation material and write gap.

Please replace the paragraph beginning at line 8 on page 7 with the following rewritten paragraph:

Figure 2A is a is a plan view ~~taken from line 2A-2A of Figure 1B~~ of a portion of a read/write head, shown greatly enlarged ~~and rotated 180 degrees~~;

Please replace the paragraph beginning at line 11 on page 7 with the following rewritten paragraph:

Figure 3 is a view similar to Figure 2B showing a read/write head of the present invention in cross section;

Please replace the heading at line 1 on page 8 with the following rewritten heading:

DETAILED DESCRIPTION OF [[THE PREFERED]] PREFERRED EMBODIMENTS

Please replace the three successive paragraphs running from line 1 on page 9 to line 2 on page 10 with the following three rewritten paragraphs:

With continued reference to Fig. 3, a first ~~insulation layer~~ insulation layer 94 covers the first pole, having a smooth flat upper surface that is flush with the smooth flat upper surface of the pedestal 92. While this first insulation layer can be of many suitable materials having a high electrical resistance it is preferably constructed of Al_2O_3.

With reference still to Fig. 3, the ~~write gap material layer 88~~ write gap material layer 89 sits atop the smooth coplanar surfaces of the first insulation layer 94 and the pedestal 92. The write gap material layer is preferably constructed of Al_2O_3 or alternatively of SiO_2. The coil 90 sits atop the write gap material layer 89 and is also covered by a second insulation layer 96, which insulates the coil 90 from the second pole 76 as well as insulating the winds of the coil 90 from one another. The second insulation layer has smoothly rounded edges formed by a curing process that will be described in greater detail below.

With continued reference to Fig. 3, the second pole 76 includes a high magnetic moment layer 98. The remainder of the second pole 76 consists of a ~~secondary layer~~ secondary layer 100, constructed of a magnetic material such as plated Ni-Fe alloy, which can be readily electroplated

and which exhibits good corrosion resistance. The high magnetic moment material layer 98, which is preferably constructed of laminated FeXN nanocrystalline films with lamination layers of $Co_{90}Zr_9Cr$, improves performance of the head by facilitating magnetic flux flow through the second pole 76, thereby resulting in a stronger fringing field at the write gap. The secondary layer 100, which preferably makes up the bulk of the second pole 76, provides a mask for etching the ~~high magnetic moment material layer 100~~ high magnetic moment material layer 98 as will be described in greater detail below. In order to minimize apex reflection during the photolithograpy process used to define the top pole, it is desirable that the edge of the ~~coil insulation layer~~ coil insulation layer 96 be placed further from the ABS than the pedestal edge, in which case the zero throat is defined by the pedestal. Apex reflection is a major source of trackwidth variation during the fabrication of the top pole. By moving the ~~coil insulation layer 100~~ coil insulation layer 96 away from the ABS and plating the second pole 76 onto a flat surface in the area near the ABS, the trackwidth can be more easily controlled. The high magnetic moment layer 98 is preferably on the order of 1 to a few times the thickness of the write gap 88. In one embodiment the high magnetic moment layer 98 is roughly 0.5 um thick while the remainder of the second pole 76 is roughly 2um thick and the pedestal is roughly 1um thick. The throat height is preferably 3-10 times the thickness of the write gap 88.

Please replace the five successive paragraphs running from line 15 on page 10 to line 17 on page 12 with the following five rewritten paragraphs:

In still another embodiment of the invention, the high magnetic moment layer 98 of the second pole 76 can be constructed of laminated FeXN nanocrystalline films with lamination layers of cobalt based amorphous ferro-magnetic alloy or alternatively of a non-magnetic dielectric material, while the pedestal is constructed of some other material such as a Ni-Fe alloy that can be electro-plated. Alternatively, the pedestal can be constructed of FeXN nanocrystalline films with lamination ~~layers a~~ layers of a cobalt based amorphous ferromagnetic ~~allow~~ alloy or of a non-magnetic dielectric material, while the high magnetic moment layer of the second pole is some other plated high magnetic moment material such as [[$NiFe_{55}$]] NiFe55.

With reference now to Figure 4, a process 400 is provided for constructing a write element of the present invention. The process begins with a step 402 of constructing the ~~first pole 94~~ first pole 74. The first pole is preferably constructed by patterning and electroplating permalloy

according to lithographic techniques familiar to those skilled in the art, and then is planarized by a chemical mechanical polishing process. Then, in a step 404 a layer of high magnetic moment (high [[Bsat]] $\underline{B_{sat}}$) material is sputter deposited onto the first pole. This sputtering process results in a layer of high [[Bsat]] $\underline{B_{sat}}$ material that completely covers the first pole as well as surrounding structure. Thereafter, in a step 406 the pedestal is patterned. A layer of photoresist is deposited so as to form a mask covering the area where the pedestal is to be formed. Then, in step 408, ion milling is performed to the sputtered high [[Bsat]] $\underline{B_{sat}}$ material not covered by the photoresist mask, thus forming the pedestal 92. The ion milling step leaves a tail of sputtered material tapering from the edge of the pedestal 92.

With further reference to Fig. 4, in a step 410 a first insulation layer 94 is deposited onto the first pole. This first insulation layer 94 is preferably constructed of Al_2O_3 and is deposited sufficiently thick to at least reach the thickness of the pedestal 92 and is preferably slightly thicker than the pedestal 92. Thereafter, in a step 412 a chemical mechanical polishing step is performed to planarize the first insulation layer 94, generating a flat planar surface across the first insulation layer 94 and the top of the pedestal 92. In a step 414 the ~~write gap material layer~~ write gap material layer 89 is deposited onto the smooth planar surface of the first insulation layer 94 and the pedestal 92. The write gap material layer can be constructed of many suitable dielectric substances, but is preferably constructed of Al_2O_3 or alternatively of SiO_2.

In a step 416, the electrically conductive coil 90 is formed. The coil is preferably constructed of copper and is formed by methods that are familiar to those skilled in the art. These methods involve first depositing a seed layer of copper or some other suitable conductive material. The coil is then patterned and electroplated, and the seed layer removed by an etching process. With the coil thus formed, in a step 418 the second insulation layer 96 is formed. The second insulation layer is preferably constructed of a photoresist, which is spun onto the write gap material 89 and the coil 90. The photoresist is patterned and exposed so that selective portions of the photoresist can be removed to provide vias for the back gap and the coil leads. Then the ~~photorsist~~ photoresist is cured by exposure to high temperatures, hardening the photoresist and providing it with smoothly rounded edges. In order to improve properties of the sputtered layer, a thin layer of dielectric material can be added to the top of the ~~photo resist~~ photoresist material.

With reference still to Figure 4, the formation of the second pole will now be described. In a step 420, a thin layer of high [[Bsat]] $\underline{B_{sat}}$ material is sputter deposited onto the structure. As will be appreciated by those skilled in the art, sputter deposition will cover the entire exposed structure, including the second insulation layer 96 and the write gap material layer 89. The high [[Bsat]] $\underline{B_{sat}}$ material is preferably constructed of FeRhN nanocrystalline films with lamination layers of CoZrCr, however other high [[Bsat]] $\underline{B_{sat}}$ materials can also be used. Then, in a step 422 the remainder of the second pole 76 is deposited. This step [[76]] involves forming a mask and then electroplating the second pole. Using such standard electroplating and photolithographic processes, the electroplated portion of the second pole 76 can be formed with the desired shape. The electroplated portion of the first pole is preferably constructed of a NiFe alloy suitable for electroplating. With the electroplated portion of the second pole acting as a mask, in a step 424 an etching process is conducted to remove the high B_{sat} material that is not covered by the plated portion of the second pole 76. This effectively results in a desired second pole 76 being primarily constructed of a magnetic material such as permalloy, and having a high B_{sat} inner layer. The resulting pole structure includes a tail (not shown) of high B_{sat} material that extends outward slightly from the edge of the pole 76, beyond the edge of the plated portion. Also, as previously discussed the ion milling step leaves some of the sputtered material re-deposited on the sidewalls of the second pole 76.

Please replace the two successive paragraphs running from line 28 on page 12 to line 18 on page 13 with the following two rewritten paragraphs:

As will be appreciated by those skilled in the art, the above process can be slightly modified to construct one of the earlier described alternate embodiments of the invention. For example, the ~~write element 66~~ write element 70 could be constructed without the pedestal by patterning the first insulation layer to terminate short of the ABS plane 86 and eliminating the pedestal deposition process. In such a case the write gap material layer would simply slope down along the edge of the first insulation layer, and would sit atop the ~~first pole 44~~ first pole 74 in the region of the write gap. Alternatively, the ~~write element 66~~ write element 70 could be constructed with a pedestal 92 as described above, but with a second pole formed without a laminated high B_{sat} layer. Furthermore, high B_{sat} layer of the second pole can be constructed of FeRhN nanocrystalline films with lamination layers of CoZrCr while the pedestal is constructed of some other magnetic

material. Similarly, the pedestal can be constructed of FeRhN nanocrystalline films with lamination layers of CoZrCr while the high B_{sat} layer of the second pole is constructed of plated high [[Bsat]] $\underline{B_{sat}}$ material such as [[$Ni_{45}Fe_{55}$]] <u>NiFe55</u>.

With reference now to Figure 5, in an alternate embodiment of the invention, the pedestal can be constructed very thin with a tapered edge. Making the pedestal thin advantageously ~~simplifying~~ <u>simplifies</u> the manufacturing process, and the tapered edge promotes flux flow into the pedestal, avoiding magnetic saturation in the pedestal. A method for constructing a write element having such pedestal is described in ~~a patent application entitled~~ <u>U.S. Patent Application No. 09/602,536, titled</u> "INDUCTIVE WRITE HEAD INCORPORATING A THIN HIGH MOMENT PEDESTAL", filed ~~on xx/xx/2000~~ <u>23 June 2000</u>, the entirety of which is incorporated herein by reference.

Please replace the Abstract with the following rewritten Abstract:

An inductive write element is disclosed for use in a magnetic data recording system. The write element provides increased data rate and data density capabilities through improved magnetic flux flow through the element. The write element includes a magnetic yoke constructed of first and second magnetic poles. The first pole includes a pedestal constructed of a high magnetic moment (high [[Bsat]] $\underline{B_{sat}}$) material, which is preferably FeRhN nanocrystalline films with lamination layers of CoZrCr. The second pole includes a thin inner layer of high [[Bsat]] $\underline{B_{sat}}$ material (also preferably FeRhN nanocrystalline films with lamination layers of CoZrCr), the remainder being constructed of a magnetic material capable of being electroplated, such as a Ni-Fe alloy. An electrically conductive coil passes through the yoke between the first and second poles to induce a magnetic flux in the yoke when an electrical current is caused to flow through the coil. Magnetic flux in the yoke produces a fringing field at a write gap whereby a signal can be imparted onto a magnetic medium passing thereby.